INDOOR AIR QUALITY ASSESSMENT

Department of Social Services
1 Arch Place
Greenfield, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
July 2005

Background/Introduction

At the request of Rosemary Sammarco, Director, Office of Facilities Management of the Massachusetts Department of Social Services (DSS), the Massachusetts Department of Public Health's (MDPH), Center for Environmental Health (CEH), provided assistance and consultation regarding indoor air quality concerns at the DSS Greenfield Office, 1 Arch Place, Greenfield, Massachusetts. The assessment was prompted by poor air quality complaints reported by building occupants. On April 1, 2005 the building was visited by Michael Feeney, Director of CEH's Emergency Response/Indoor Air Quality (ER/IAQ) Program to conduct an IAQ assessment.

The DSS office occupies the first floor of a three-story office building constructed in 1993. The building is attached to a garage and a hardware store. Unoccupied office space is immediately adjacent to the garage on the DSS floor. A food establishment and public restrooms are located at the front of the building. The DSS office is divided into private offices and cubicles using four foot tall dividers (Picture 1).

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. MDPH staff also performed visual inspection of building materials for water damage and/or microbial growth. Water content of gypsum wallboard was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The DSS office has an employee population of approximately eighty and approximately 50 individuals visit the offices daily. Tests were taken under normal operating conditions and results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that the carbon dioxide levels were above 800 parts per million (ppm) in nineteen of thirty two areas surveyed, indicating inadequate air exchange in over half of the areas surveyed. Please note, most areas surveyed that had carbon dioxide measurements below 800 ppm were sparsely populated or unoccupied, which can greatly reduce carbon dioxide measurements.

Mechanical ventilation is provided by a heating, ventilation and air conditioning (HVAC) system powered by three air-handling units (AHUs) located above the ceiling of the DSS offices. Fresh air intakes for these AHUs are located ten feet above the ground along the rear wall of the building. Ductwork connects the AHUs to ceiling-mounted, fresh air supply diffusers. By design, air diffusers are equipped with fixed louvers, which direct the air supply along the ceiling to flow down the walls and create airflow.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and return system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings ranged from 71 ^{o} F to 75 ^{o} F, which were within the MDPH recommended comfort range. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

Relative humidity measurements ranged from 28 to 34 percent, which were below the MDPH comfort guidelines. The MDPH recommends that indoor air relative humidity be maintained in a comfort range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Humidity is more difficult to control during the winter heating season. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Room 138 was examined for possible mold contamination. In order for building materials to support mold growth, a source of moisture is necessary. Identification and elimination of water moistening building materials is necessary to control mold growth. Building materials with increased moisture content over normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth.

As indicated, moisture content of gypsum wallboard (GW) in room 138 was measured with a Delmhorst Moisture Detector equipped with a Delmhorst Standard Probe. The

Delmhorst probe is equipped with three lights that function as visual aids that indicate moisture level. Readings that activate the green light indicate a sufficiently dry or low moisture level, those that activate the yellow light indicate borderline conditions and those that activate the red light indicate elevated moisture content. No elevated moisture readings were measured during the assessment. In addition, a thorough visual examination was conducted and no visible mold growth or associated evidence of water damage (e.g., stains, odors) was observed and/or detected during the assessment. Based on this examination, it appears that mold is not a likely source of respiratory irritants in room 138. The restroom and storeroom walls shared with room 138 were also free of water damage and mold.

An office at the front of the building (room 123) appears to have an exterior wall that consists of a single metal panel (Picture 2). Without insulation, this panel would become chilled rapidly in cold weather and may be a source of condensation and contribute to thermal discomfort (cold complaints). Condensation is the collection of moisture on a surface that has a temperature below the dew point. The dew point is a temperature that is determined by air temperature and relative humidity. For example, at a temperature of 76^{o}F and a relative humidity of 30 percent, the dew point for water to collect on a surface is approximately 43^{o}F. At a temperature of 85^{o}F and a relative humidity of 90 percent, the dew point for water to collect on a surface is approximately 82^{o}F. Therefore, if a surface has a temperature under 83^{o}F, water vapor will form droplets on that surface. Prolonged wetting of porous building materials by condensation can lead to subsequent mold growth.

Plants were noted in areas throughout the DSS offices. Plants, soil and drip pans can serve as sources of mold growth. Plants should be properly maintained, over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth.

Other Concerns

Several other conditions that can potentially affect indoor air quality were identified. DSS occupants reported a particular problem with room 138. In addition to moisture sampling, CEH staff examined the room as well as the space above the suspended ceiling (called the ceiling plenum). CEH staff noted that air was blowing from the ceiling plenum into the office when a ceiling tile was removed. Ceiling plenums are expected to either be depressurized when used as part of the return system in a building (in this case, it is not) or have neutral pressure. This pressurization was attributed to flexible ductwork that was not connected to the HVAC system (Picture 3). The unconnected flexible duct appeared to be a source of air movement above the ceiling in this area. Under these circumstances, settled dust, dirt and other accumulated debris above the suspended ceiling can be agitated by this airflow, which may then pass through the ceiling system into occupied areas. This phenomenon appears to be localized and possibly enhanced by the location of room 138, which is at the end of a row of offices (Figure 1). This room has two walls that are shared with a hallway and a third shared with the adjoining office (room 137). The fourth is a floor to roof decking wall that separates the DSS offices from the restaurant/public restrooms. The open flexible duct blows air from the wall shared with room 137 across the ceiling of room 138, and likely forces debris above the ceiling into the occupied space. Aerosolized dust, dirt and debris can be sources of respiratory irritants.

Building occupants reported that vehicle exhaust and odors associated with grass cutting are periodically detected in offices, particularly in the northeast corner of the building.

There appear to be two possible sources of vehicle exhaust odors. The north wall of the DSS building is connected to a garage. A door in the garage appears to open into the DSS building (Pictures 4 and 5). If this door and wall are not airtight, products of combustion from vehicles can penetrate into the building. Exhaust emissions can be a source of odors and particulates that can be irritating to the eyes, nose, throat and respiratory system. Another likely source is the operation of lawn mowing equipment along the rear wall of the building. As previously stated, fresh air intakes for the first floor are located along the rear wall of the building ten feet above the ground (Picture 6). If grass mowing is conducted or vehicles operate behind the building during office hours, vehicle exhaust, grass, pollen, dirt and other debris can become aerosolized, captured by the ventilation system and introduced into the building.

Air handling units are normally equipped with filters that strain particulates from airflow. Filters for this system are installed within the return vent frame and are of a low efficiency that provides a minimum of filtration. CEH staff could not determine whether fresh air intakes were equipped with air filters. If fresh, unfiltered air is drawn into the AHUs, particulates would likely be distributed into the DSS office. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced through increased resistance (called pressure drop). Prior to any increase of filtration, each AHU should be evaluated by a ventilation engineer to ascertain whether it can maintain function with more efficient filters.

Conclusions/Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Reattach the flexible duct above room 138 to the appropriate air diffuser. If the flexible vent is not meant to be connected to an existing air diffuser, remove the flexible duct and seal its connection to the metal supply duct.
2. Contact an HVAC engineering firm to evaluate AHUs and increase fresh air supply to the DSS offices.
3. Operate the ventilation system continuously during periods of occupancy independent of room thermostat control to maximize air exchange.
4. Examine fresh air supplies for filters. If no filters exist, install a means to install filters for fresh air intakes.
5. Change filters as per the manufacture's instructions or more frequently if needed.
6. Consider increasing the dust-spot efficiency of HVAC filters. Prior to any increase of filtration, each piece of air handling equipment should be evaluated by a ventilation engineer as to whether it can maintain function with more efficient filters.
7. Make arrangements for grass cutting to be conducted after DSS office hours. If not feasible, minimize fresh air intake temporarily until grass cutting or vehicle activity is complete.
8. Render the door, door frame and shared wall of garage as airtight as possible using weather-stripping, door sweeps and sealing all open seams/holes with a fire rated sealant.

9. Determine if the garage contains a mechanical exhaust ventilation system, if not, a system should be installed in the garage to remove vehicle exhaust emissions.

10. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

11. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

12. Install an insulated panel in the exterior wall of room 123 to reduce heat loss and prevent condensation.

References

ASHRAE. 1992. Gravimetric and Dust-Spot Procedures for Testing Air-Cleaning Devices Used in General Ventilation for Removing Particulate Matter. American Society of Heating, Refrigeration and Air Conditioning Engineers. ANSI/ASHRAE 52.1-1992.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

MEHRC. 1997. Indoor Air Quality for HVAC Operators & Contractors Workbook. MidAtlantic Environmental Hygiene Resource Center, Philadelphia, PA.

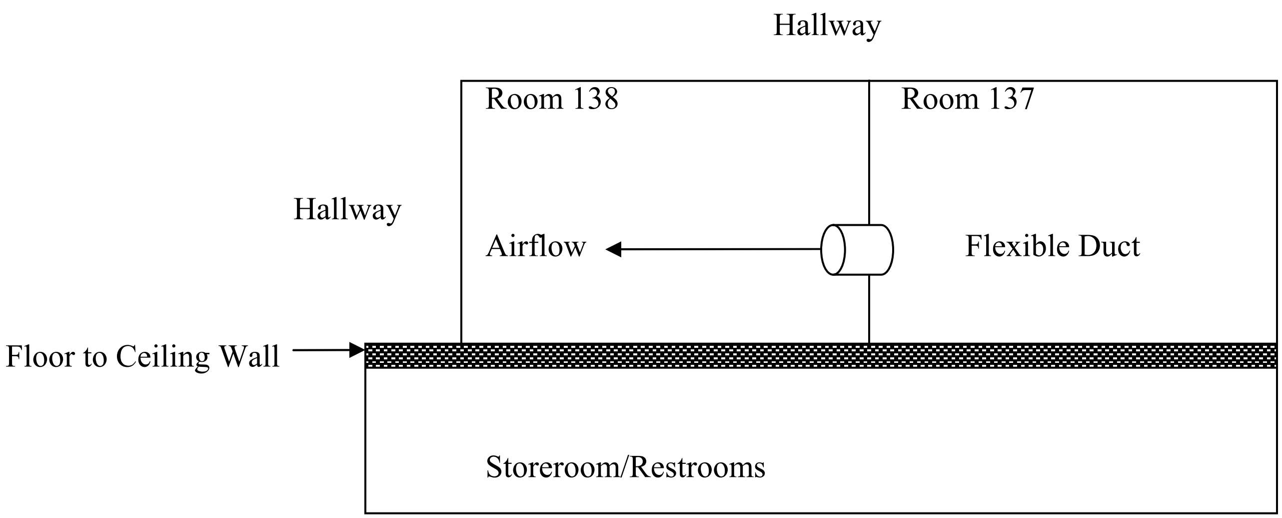
OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R. 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Thornburg, D. 2000. Filter Selection: a Standard Solution. *Engineering Systems* 17:6 pp. 74-80.

Figure 1
Airflow of Open Flexible Vent above Room 138



Picture 1

Typical Floor Divider

Picture 2

Single Exterior Wall Panel behind Heater, Room 123

Picture 3

Disconnected Flexible Duct

Picture 4

Garage Adjacent To DSS Offices

Picture 5

Door in Garage Shared With First Floor of DSS Offices

Picture 6

One of Three Likely Fresh Air Intake of DSS Offices

TABLE 1
Indoor Air Test Results
Department of Social Services, 1 Arch Place, Greenfield, Massachusetts
April 1, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	430	65	44					
110	868	71	34	2	N	Y	Y	Door open
107	862	72	32	1	N	Y	N	
111	896	73	31	0	N	Y	N	Plants Door open
112	802	73	31	0	N	Y	N	Door open
113	866	73	31	1	N	Y	N	Door open
114	940	73	31	1	N	Y	N	Plants
115	816	73	31	0	N	Y	N	Plants Door open
116	812	72	31	0	N	Y	N	Door open
117	813	73	30	1	N	Y	N	Plants

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1
Indoor Air Test Results
Department of Social Services, 1 Arch Place, Greenfield, Massachusetts
April 1, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
119	820	73	30	0	N	Y	N	Door open
121	834	73	29	3	N	Y	N	
122	826	73	29	1	N	Y	N	Door open
126	874	75	28	3	N	Y	Y	Plants
125	885	75	29	1	N	Y	Y	
123	837	74	28	1	N	Y	N	Plants
129c	805	73	29	4	N	Y	Y	1 water-damaged ceiling tile
130	826	73	30	1	N	Y	Y	Plants
131	747	73	29	1	N	Y	Y	Door open
132	756	73	30	0	N	Y	Y	Door open

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1
Indoor Air Test Results
Department of Social Services, 1 Arch Place, Greenfield, Massachusetts
April 1, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
136	737	74	29	0	N	Y	N	Door open
137	714	73	29	0	N	Y	N	Door open
138	722	73	29	0	N	Y	N	Door open
144	737	73	29	0	N	Y	Y	Door open
142	732	73	29	3	N	Y	Y	Door open
143	767	73	29	1	N	Y	Y	
153	831	74	29	2	N	Y	Y	Vehicle exhaust reports
152	733	73	29	0	N	Y	N	Door open
150	824	73	30	2	N	Y	N	Door open
149	799	74	29	0	N	Y	N	

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1
Indoor Air Test Results
Department of Social Services, 1 Arch Place, Greenfield, Massachusetts
April 1, 2005

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
148	750	74	29	2	N	Y	N	
147	727	74	29	1	N	Y	N	Plants
146	729	74	28	0	N	Y	N	Plants Door open
145	722	74	28	0	N	Y	N	Door open

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%